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Sector Growth and the Dual Economy Model

Evidence from Côte d'Ivoire, Ghana, and Zimbabwe

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Focusing mainly on industry has not been optimal policy in Côte d'Ivoire, Ghana, and Zimbabwe For maximum economywide growth, it would have been better to balance policies to facilitate growth in all three sectors agriculture, industry, and services

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Summary findings

Blunch and Verner analyze and compare sectoral growth in three African economies — Côte d'Ivoire, Ghana, and Zimbabwe — since 1965.

They extend the classic dual economy — the agriculture and industry sectors — by adding the services sector.

For all three countries, they find at least one statistically significant long-run relationship for sectoral GDP. This indicates a large degree of interdependence in long-run growth among the three sectors.

This also provides evidence against the basic dual economy model, which implies that a long-run relationship cannot exist between agricultural and industrial output.

Analysis of the impulse response and analysis of short-run sectoral growth support the results on the interdependence of sectoral growth. Both imply that a positive link exists between growth in industry and growth in agriculture.

Their findings contradict the literature on the dual economy — and suggest that more attention should be paid to intersectoral dynamics and dependencies in Sub-Saharan Africa. Why? Because an adverse shock in, say, agriculture after a drought is likely to have an adverse impact on other economic sectors. Policymakers should try to accommodate not only the initial shock in agriculture but also its adverse effects in other sectors.

They find that focusing mainly on industry was not optimal policy in Côte d'Ivoire, Ghana, and Zimbabwe. For maximum economywide growth, it would have been better to balance policies to include all three sectors: agriculture, industry, and services.

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Sector Growth and the Dual Economy Model: Evidence from Côte d'Ivoire, Ghana, and Zimbabwe

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1. Introduction

With the increased interest in growth theory, empirical work on economic growth has expanded enormously in the last decade. Most of this literature mainly focuses on the determinants of aggregate economic growth, however, while there has been less emphasis on sectoral economic growth. The sectoral growth literature builds mainly on the dual economy model originating in Lewis (1954) and Hirschmann (1958). This model seeks to explain economic growth by emphasizing the roles of agriculture and industry and the interplay between them.[1] The dual economy model views the agricultural sector as the basis of an emerging economy, a generator of the capital necessary for take-off toward the second stage of economic development, industrialization. Once industrialization has taken place, the agricultural sector becomes redundant.

The dual economy literature generally rules out two major issues, both of which seem quite intuitive, about the later stages of economic development. First, the literature denies that agriculture may be an important growth-promoting factor. Second, it rules out feedback mechanisms between agriculture and industry. Recent developments in the sectoral growth literature dispute this view of the dual economy model. Gopinath, Roe, and Shane (1996) address these issues, analyzing the possible link between agriculture and food processing. Productivity gains in agriculture are allowed to feed back into the food processing industry, where they lead to cheaper inputs. Lower priced inputs lead in turn to increased derived demand for primary agricultural products, thus partly mitigating the price decline. The two sectors evolve interdependently over time, contrary to what the dual economy model predicts.

Martin and Mitra (1998) analyze total factor productivity growth and convergence in agriculture and manufacturing for a large sample of countries at all levels of economic

[1] Several recent studies build upon a framework along the lines of this classical dualistic framework. In Canning (1988), growth comes about through migration of labor from agriculture into industry. Depending on the magnitude of the increasing returns in industry, and assuming that the economy does not take-off near subsistence level, the economy may exhibit sustained long-run growth. Matsuyama (1992) let growth emerge as learning-by-doing in manufacturing. Assuming an income elasticity of demand for agricultural goods less than unity, a positive association between agricultural productivity and economywide growth is found for the case of a closed economy. In an open economy scenario, however, a negative link is found, implying that focusing on the agricultural sector would slow down the overall growth of an economy. Several case studies exist. For example, Skott and Larudee (1998) focuses on Mexico, Storm (1997) analyzes the case of India, and Yao (1996) analyzes sectoral growth in China.

development. They find less convergence in manufacturing productivity than in agricultural productivity. Also, they find the rate of productivity growth to be higher in agriculture than in manufacturing. This is contrary to the traditional view that productivity growth is higher in industry than in agriculture.[2] If that belief is wrong, there are important consequences for developing economies, which have historically implemented policies based on this view, resulting in strong policy biases against investment in the agricultural sector (Krueger, Schiff, and Valdes 1992).

In this paper, we investigate the applicability of the dual economy model to developing countries. We analyze economic growth in Sub-Saharan Africa, emphasizing the role of agriculture in generating economic growth and highlighting possible dynamics between agriculture and industry. We compare sectoral growth in Côte d'Ivoire, Zimbabwe, and Ghana. Four main questions motivate the analysis. First, do the agricultural, industrial, and services sectors evolve interdependently in the long run? Second, if they do, is there a link between agricultural and industrial growth, thus contradicting the dual economy model? Third, do sectors adjust toward a long-run equilibrium after having been exposed to economic shocks? Fourth, is the policy bias against the agricultural sector valid or should it be abandoned in favor of a more diverse policy strategy across sectors?

Section two presents the economic model and the econometric framework applied in the paper. Section three describes the data and preliminary data analysis. Section four analyzes sectoral growth, applying the co-integration framework and impulse response techniques, and estimates a short-run sectoral growth model.

2. The Economic Model and the Econometric Framework

In analyzing sectoral growth in Sub-Saharan Africa, we focus on the question of whether, contrary to the dual economy model, sectors evolve interdependently, focusing in particular on the dynamics between agriculture and industry. A priori the analysis should ascribe importance to such exogenous events as droughts, trade shocks, and policy changes, which are all likely to affect sectoral growth. These issues must be explicitly

[2] See, for example, Syrquin (1986).

incorporated in the economic model. These considerations give rise to the following model:

(1) $y_j = y(y_a, y_i, y_s, \gamma)$

where y_j denotes the economic size of sector j, $j = \{a$ (agriculture), i (industry), and s (services)$\}$.[3] The variable γ denotes all other factors that may affect sectoral growth, such as institutional setting, legislation, and internal and external shocks.

In order to estimate the model, we need to quantify the economic size of the sectors. We choose the simplest specification possible, defining the economic size of a sector by its output. The residual of a statistical regression model captures the additional factors likely to affect sectoral output. Hence, the output of a sector depends on the production of that sector as well as that of the other sectors. We apply the econometric framework of co-integration (originating with Engle and Granger 1987), which allows for testing economic hypotheses regarding possible sectoral interdependencies by testing parameter restrictions. Evidence of a long-run relation among the growth of sectors would indicate a large degree of interdependence in long-run sectoral growth in Sub-Saharan Africa and would thus provide evidence questioning the validity of the dual economy model.

Because of the possibility of more than one co-integrating relation, we apply full information maximum likelihood (FIML) techniques to test for the order of the co-integrating rank (Johansen 1988, 1991).[4] Consider the vector auto regression (VAR):

(2) $$x_t = \rho + \sum_{i=1}^{I} \xi_i x_{t-i} + \varepsilon_t, \qquad \varepsilon_t \sim \mathrm{NIID}(\mathbf{0}, \Omega^2)$$

where x_t and ε_t are $1 \times p$ vectors, ξ_i is a $p \times p$ coefficient matrix, and ρ is a $1 \times p$ vector of constants. First-order differencing and re-arranging equation 2 yield the following error correction model (ECM):

(3) $$\Delta x_t = \rho + \sum_{i=1}^{k-1} \Gamma_i \Delta x_{t-i} + \Pi x_{t-k} + \varepsilon_t, \quad \varepsilon_t \sim \mathrm{NIID}(\mathbf{0}, \Omega^2)$$

[3] Note that if the analysis specified the variables instead as changes in economic size, it would model sectoral short-run growth. We do this later in the paper.

[4] In the case of more than two variables in the co-integrating relation, the estimated co-integrating vector may not be unique; see Engle and Granger (1987).

where Γ_1=Π_1-I, Γ_2=Π_2+Γ_1, Γ_3=Π_3+Γ_2, etc. Hence, Π=I-Π_1-...-Π_k. The rank of the Π matrix determines whether the series co-integrate. There are three possible cases. In the first case, rank(Π)=p, which is full rank, where x_t is stationary and there is no co-integration since a necessary condition for the series to exhibit co-integration is that at least two of the series be integrated. In the second case, rank(Π)=0 and Δx_t is stationary and, again, there is no co-integration. Hence, the model must be respecified in first-order differences, that is, as a difference VAR. In the third case, rank(Π)=r<p, implying reduced rank, and the series co-integrate, with the number of co-integrating relations given by r.

We use the Johansen (1988, 1991) procedure, thus estimating all linear combinations of the lagged variables in levels that are highly correlated with the first-order differences. If Π has reduced rank r, that is, if $0<r<p$, it may be split into two $p\times r$ matrices α and β, such that $-\Pi=\alpha\beta'$. We estimate the ECM system (equation 3), subject to the restriction that $-\Pi=\alpha\beta'$ for r=0,1,..., p-1, by means of maximum likelihood. This is followed by a test for the order of r.[5]

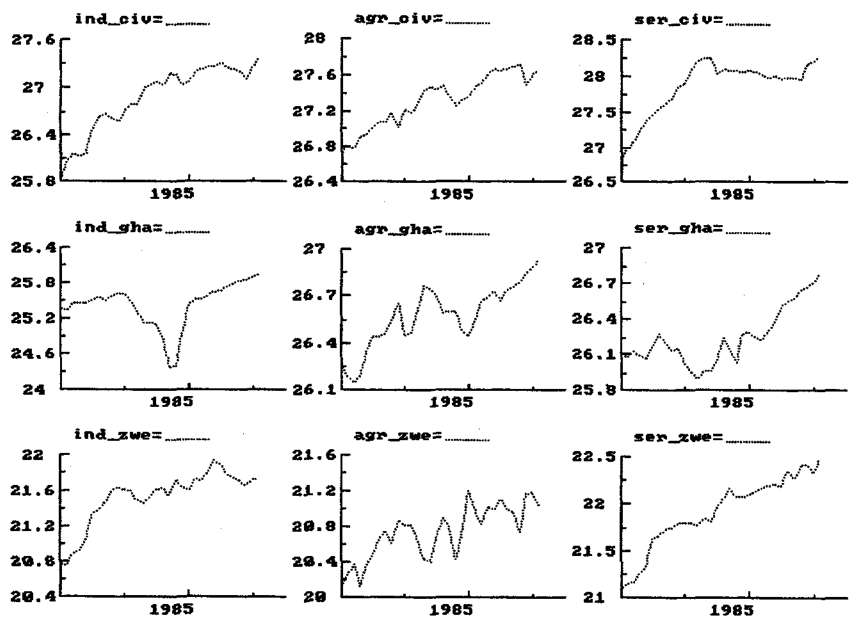
Until the test for the co-integrating rank, the analysis involves multidimensional Wiener-processes. However, once the number of co-integrating relations, r, has been determined, $\beta'Y$ will be stationary, and further tests on the α and β matrices and deterministic terms will, conditional on r, be distributed χ^2. The columns of β are the co-integrating parameter vectors or, correspondingly, the columns of β span the co-integrating space. Thus, any linear combination of these is also a co-integrating relation. The coefficients in α can be interpreted as factor loadings measuring the relative importance of a deviation from equilibrium on a given endogenous variable. Factor loadings are short-run parameters; thus, we have partitioned Π into short- and long-run parameters.

[5] Note that the squared values of the above-mentioned canonical correlations correspond to the eigenvalues of Π, implying that the problem at hand is an eigenvalue problem, that is, determining the number of eigenvalues that are significantly different from zero. The estimated eigenvalues are ranked according to their magnitudes and the co-integrating rank can be determined by performing a nonstandard distributed likelihood-ratio test, using the result (from linear algebra) that the rank of a matrix = #eigenvalues≠0.

3. Three Sub-Saharan African Economies

This section describes the data used in the empirical analysis and provides a sketch of the economies of Côte d'Ivoire, Ghana, and Zimbabwe. The data used in the analysis are the (log) real GDP in the industry, agriculture, and service sectors from the World Bank African Regional Database for 1965-97 (figure 1).[6] The plots reveal an overall positive trend in all output series.[7] First-order differences of the series (not shown) appear stationary, indicating that the series are integrated of order one, I(1). This is further supported by results from augmented Dickey-Fuller tests (see the appendix). Therefore, the series may possibly co-integrate.

Figure 1. Sectoral GDP for Côte d'Ivoire, Zimbabwe and Ghana



Note: The series are log(real GDP, factor prices) -- ind: industry, agr: agriculture, ser: service, civ: Cote d'Ivoire, zwe: Zimbabwe, gha: Ghana.
Source: World Bank African Regional Database.

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[6] For Ghana, however, the series end in 1996.

[7] Ghanaian industrial output experiences a major collapse in the early 1980s, which may make possible subsectoral relationships disappear. This proves to be the case in the co-integration analysis in the next section; accordingly, we propose disaggregating Ghanaian industrial output into the four subsectors manufacturing, construction, gas and water, and mining.

The sectoral growth performance is closely related to the development of the three economies since 1965. All three countries have been through major economic crises followed by structural adjustment programs aimed at restoring macroeconomic stability and increasing overall growth of the economy. In the following, we will briefly sketch the economic development of the three countries.

3.1. Côte d'Ivoire

Côte d'Ivoire has an income per capita of $660 (in 1995). The agricultural sector accounts for 31 percent of GDP, and generates 70 percent of export revenues (table 1). Its main exports are cocoa, coffee, and timber. Starting in the early 1980s, Côte d'Ivoire experienced a severe economic and social crisis. The crisis began with macroeconomic imbalances that had grown to unsustainable levels: a budget deficit of about 10 percent of GDP and a current account deficit of about 17 percent of GDP. Public expenditures had increased markedly following the cocoa and coffee price booms of 1975-77, but then were not reduced as the booms ended. With the rapid build-up of external debt in the 1970s, Côte d'Ivoire started to encounter serious debt servicing problems. Tightly controlled and restrictive policies, including trade barriers and price interventions, began to create serious distortions in domestic markets in the 1980s. Most notably, these distortions resulted in inefficient resource allocation.

Table 1. Distribution of Gross Domestic Product in Côte d'Ivoire, Ghana, and Zimbabwe (percent)

	Agriculture		Industry		Services		Manufacturing	
Country	1980	1995	1980	1995	1980	1995	1980	1995
Côte d'Ivoire	27	31	20	20	53	50	13	18
Zimbabwe	14	15	34	36	52	48	25	30
Ghana	58	46	12	16	30	38	8	6

Source: World Bank 1997.

Adjustment policies introduced before 1987 were only partially successful in reducing the main internal and external imbalances. During the 1990s, the government initiated more widespread structural reforms, supported by the World Bank and the IMF.

In 1994, a privatization law was adopted, which aimed at privatizing publicly owned enterprises. Restrictive wage policies combined with tax reform began to bring inflation under control. The government wage bill decreased significantly, from 10.7 percent of GDP in 1993 to 6.9 percent in 1995. Other policies included deregulation of the agricultural sector, aimed at reducing public intervention and obtaining more flexible producer prices. The structural reforms and high international prices for cocoa and coffee led to widespread increases in private investments.

3.2. Zimbabwe

Zimbabwe has an income per capita of $540 (in 1995). Zimbabwe pursued an import substitution strategy up until 1980. Worldwide economic sanctions were imposed on the regime during this so-called Unilateral Declaration of Independence period (1965-80). As a result of the sanctions, which closed Zimbabwe off from much of world trade, the country ended up with one of the most developed manufacturing sectors in Sub-Saharan Africa. In the early 1980s, mining, manufacturing, and agriculture each accounted for more than 20 percent of GDP, contrasting with many African economies, which are mainly based on agriculture.

Agricultural output in Zimbabwe is highly variable, a consequence of low and erratic rainfall and frequent droughts. Two particularly damaging droughts in 1991-92 and 1995 led to a drop in agricultural output. Recently, attention has been given to the development and promotion of more drought-resistant crops and improvements in water resource management. Also, reform programs were initiated after the declaration of independence in 1980. For agriculture these consisted largely of increased attention to smallholder agriculture.

The strict control of the Zimbabwean economy necessitated by the economic sanctions continued after the declaration of independence. During the 1980s, it became clear that this was not the road to prosperity as investments and export-led growth in both manufacturing and commercial agriculture were hampered. Furthermore, increased social service and military spending increased public deficits as the conflict with Mozambique became more visible by the late 1980s.

The government sought to increase growth by introducing a more flexible exchange rate policy and relaxing controls on investment and exports, leading up to the launching of the IMF and World Bank economic structural adjustment program in 1990. This program further focused on deregulating the economy—prices, employment, wages, and trade—and on reducing the public deficit. Through this program, the Zimbabwean government wanted to send a signal of its policy shift from intervention and regulation toward deregulation and privatization (see Marquette 1997).

3.3. Ghana

Ghana has an income per capita of $390 (in 1995), which makes it the poorest of the three economies analyzed. The agricultural sector accounts for almost half of GDP (in 1995). Ghana has the least developed manufacturing sector, which accounts for only 6 percent of GDP (table 1). Its service sector is also less developed than that of Côte d'Ivoire and Zimbabwe, where the service sector accounts for around half of GDP.

The period from 1965 to the mid 1970s was characterized by expansion in agriculture and services, as Ghana maintained its position as the world's leading cocoa producer. From the mid-1970s to the mid-1980s, declining cocoa production and trade restrictions posed major obstacles to continued economic growth. Further, the return of more than a million Ghanaians from Nigeria in 1982-83 and a prolonged drought in 1982 accelerated the sectoral decline, resulting in historically low output levels in 1984 for all sectors. In response to the crisis, the government, with IMF and World Bank support, initiated the Economic Recovery Program (ERP) in 1983. The program aimed at restoring macroeconomic stability, encouraging savings and investment, creating an enabling environment for the private sector, and improving public sector management, including privatization of some of the many publicly owned enterprises.

Other changes also took place. The monopoly power of the Cocoa Board was broken, allowing farm produce prices to rise toward world market prices and, in turn, stimulating cocoa production. Trade liberalization measures were introduced, including an auction system for foreign exchange to replace a fixed exchange system with controls. The changes resulted in increased investments in imported technology and spare parts, which had long been lagging because of the trade restrictions. Financial sector reforms were also introduced; in the late 1980s, ceilings on interest rates were removed and nonperforming assets of the banking system were written off (Montiel 1995). These measures led to increased economic activity in the Ghanaian economy, as revealed by the substantial positive trend in sectoral output for all series from 1985 onward (figure 1).

4. Sectoral Growth Analysis

To determine whether there are common sectoral components and feedback mechanisms in sectoral long-run growth in Sub-Saharan Africa, we examine the long-run properties of the series by performing co-integration and impulse response analysis. Specifically, we analyze whether there is a positive agriculture-industry link. We also examine the short-run properties of sectoral growth in Sub-Saharan Africa to identify the determinants of sectoral growth in the short run, including whether the sectors adjust when departing from long-run equilibrium growth.

4.1. Long-Run Sectoral Growth

The starting point is to formulate a parsimonious VAR that does not violate the design criteria. We experiment with various lag augmentations as well as a deterministic trend, while always ensuring that the specification criteria are fulfilled, that is, normally, identically, distributed residuals. For Zimbabwe, a specification with two lags and a trend is found to be suitable. For Ghana and Côte d'Ivoire, it is not possible to go below five lags without severely violating the specification criteria. For these two countries, we do not include a deterministic trend due to the risk of overfitting the model. These specifications are seen to be in accordance with the model specification criteria (table 2). The next step is to test for co-integration in the parsimonious VAR. The eigenvalues and corresponding log-likelihoods from the estimation of the Π matrix from equation 3 and test statistics are presented in tables 3 and 4.

Table 2. Misspecification Tests for the Co-integration Vector Auto Regression

Country and industry	AR-test	Normality-test	ARCH-test	RESET-test
Single-equation analysis				
Côte d'Ivoire	$F_{ar}(1, 11)$	$\chi^2_{normality}(2)$	$F_{arch}(1, 10)$	
Industry	0.354	2.027	0.088	--

Agriculture	0.236	3.864	0.082	--
Services	0.000	0.625	0.203	--
Zimbabwe	$F_{ar}(1, 22)$	$\chi^2_{normality}(2)$	$F_{arch}(1, 21)$	$F_{reset}(12, 10)$
Industry	0.036	1.414	0.000	0.440
Agriculture	0.707	0.000	2.908	0.556
Services	0.083	0.525	0.242	0.667
Ghana	$F_{ar}(1, 10)$	$\chi^2_{normality}(2)$	$F_{arch}(1, 9)$	
Industry	0.211	2.9	0.001	--
Agriculture	0.066	1.864	0.679	--
Services	0.557	0.947	0.863	--
Vector analysis				
Côte d'Ivoire	$F_{ar}(9, 17)$	$\chi^2_{normality}(6)$		
	1.345	4.22	--	--
Zimbabwe	$F_{ar}(9, 43)$	$\chi^2_{normality}(6)$	$F_{arch}(72, 33)$	
	1.782	1.17	0.430	--
Ghana	$F_{ar}(9, 14)$	$\chi^2_{normality}(6)$		
	0.740	6.630	--	--

Note: -- implies that the test statistic could not be computed.
Source: Authors' calculations.

Table 3. Eigenvalues and Log-Likelihoods

	Côte d'Ivoire		Zimbabwe		Ghana	
Rank	Eigenvalue	Log-likelihood	Eigenvalue	Log-likelihood	Eigenvalue	Log-likelihood
0		245.458		210.334		231.872
1	0.618	258.919	0.523	221.797	0.374	238.188
2	0.354	265.030	0.248	226.217	0.207	241.315
3	0.007	265.132	0.197	229.626	0.028	241.700

Source: Authors' calculations.

Table 4. Eigenvalues and Log-Likelihoods for Ghana, Sub-sectoral Specification

Rank	Eigenvalue	Log-likelihood
0		383.189
1	0.841	410.730
2	0.806	435.318
3	0.570	447.959
4	0.358	454.613
5	0.220	458.340
6	0.119	460.247

Source: Authors' calculations.

The findings reveal the existence of one co-integrating relationship in sectoral GDP for Côte d'Ivoire and Zimbabwe (table 5).[8] For Ghana, no co-integration is present, possibly due to aggregation, as industry consists of the sectors manufacturing, construction, gas and water, and mining (table 5). The proposed dynamics between the agricultural sector and food processing, which is part of manufacturing, may vanish during aggregation. Specifically, a possible relationship between agriculture and manufacturing would possibly vanish in the substantial fall in overall industry GDP in the early 1980s (figure 1). Specifying a model with industrial GDP disaggregated into subsectors could accommodate this possibility. Doing this leads to a final specification with two lags and a deterministic trend. The test statistics resulting from the misspecification tests of this alternative model are presented in table 7. The overall impression is that this specification also appears to be well specified, with only minor signs of autocorrelation.

Table 5. Test for Co-Integrating Rank, Aggregate Model

	Côte d'Ivoire		Zimbabwe		Ghana	
H_0:rank=p	λ_{max}	Trace	λ_{max}	Trace	λ_{max}	Trace
p=0	26.92**	39.35**	22.93	38.58**	12.63	19.66
p≤1	12.22	12.42	8.841	15.66	6.254	7.024
p≤2	0.204	0.204	6.818**	6.818**	0.770	0.770

** Rejection at a 1 percent level of significance.
Source: Authors' calculations.

Table 6. Test for Co-Integrating Rank for Ghana, Sub-sectoral Specification

H_0:rank=p	λ_{max}	Trace
p=0	55.08**	154.1**

[8] This result comes about by starting at the top of table 5 and moving downward until H_0 cannot be rejected. As this is the case in the second row, the analysis maintains the H_0 of one or less co-integrating vectors. As it previously rejected the H_0 of zero co-integrating vectors, this implies the existence of exactly one co-integrating vector for the cases of Côte d'Ivoire and Zimbabwe. Note that the λ-max test is cursed with serious size distortions asymptotically, that is, as $T \rightarrow +\infty$ (where T is the sample size), implying that attention should be directed to the results of the trace test rather than the λ-max test.

p≤1	49.18**	99.03
p≤2	25.28	49.86
p≤3	13.31	24.58
p≤4	7.455	11.27
p≤5	3.814	3.814

** Rejection at a 1 percent level of significance.
Source: Authors' calculations.

Table 7. Misspecification Tests for Co-Integration Vector Auto Regression for Ghana, Sub-sectoral Specification

Industry			
Single-equation analysis	$F_{ar}(1, 15)$	$\chi^2_{normality}$ (2)	$F_{arch}(1, 14)$
Manufacturing	0.081	1.298	0.000
Agriculture	4.021	5.369	1.423
Services	0.003	2.396	0.146
Mining	0.141	0.706	0.001
Construction	0.290	1.723	0.476
Gas and water	2.372	1.699	0.185
Vector analysis	$F_{ar}(36, 24)$	$\chi^2_{normality}(12)$	
	2.155*	13.222	

* Rejection at a 5 percent level of significance.
Source: Authors' calculations.

The Johansen test for this alternative specification reveals the existence of two distinct co-integrating relationships. This result supports our earlier hypothesis of subsectoral dynamics possibly vanishing in the course of aggregation to the industry level.

The co-integrating rank is restricted to one for Côte d'Ivoire, one for Zimbabwe, and two for Ghana. Tests of overidentifying restrictions on the α and β vectors may now be carried out. For α, the main test of interest is that of weak exogeneity of a particular variable with respect to β. This test is carried out by restricting the adjustment coefficients of the variable in question to zero. This amounts to testing whether the variable in question adjusts to deviations from equilibrium (which is the interpretation of the co-integrating relation). If all the α coefficients of a particular variable can be restricted to zero, then we may condition on this variable in the further analysis. That is, we may remove it from the left-hand side of the equation and it becomes exogenous to the remaining system. If this is the case, this particular variable drives the system of equations. Regarding β, there is no "right" size of the intersectoral dependency from a theoretical point of view, as long as the elasticities are within the range [-1,1]. We suggest testing for unit elasticity between sectors, which may be interpreted as "full sectoral spillover."

For Ghana, hardly any of the elasticities are close to one; hence, unity restrictions give rise to very large changes in the other parameters. Therefore, we focus on the issue of exogeneity and take the estimated co-integrating restrictions as given. We apply the restrictions directly as error correction terms in the short-run analysis.[9]

Table 8 presents the findings. In each case, the first specification applies only a normalizing restriction (except for Ghana, which requires normalizing and identifying restrictions). The second specification is the overidentified, or testable, co-integrating vector. The restricted co-integrating relations are presented in tables 9 and 10.

Table 8. Tests of Co-Integrating Restrictions

Restriction(s)	Log-likelihood	χ^2-stat.	Degrees of freedom
Côte d'Ivoire			
$\beta_{ind}=1$	258.919		
$\beta_{ind}=1\text{-}1\wedge\alpha_{ser}=0$	258.124	1.591	2
Zimbabwe			
$\beta_{ind}=1$	221.797		
$\beta_{ind}=1\wedge\beta_{agr}=\beta_{ser}=-1\wedge\alpha_{ser}=0$	220.114	3.367	3
Ghana			
$\beta_{man}=1$	435.318		
$\beta_{man}=1\wedge\alpha_{agr}=\alpha_{ser}=\alpha_{con}=\alpha_{gas}=0$	428.053	14.53	8

Note: In the subscripts for the variables in the restrictions, ind denotes industry; agr, agriculture; ser, service; man, manufacturing; min, mining; con, construction; and gas, gas and water. Note that for the case of Ghana, the tests implies restrictions on both of the β and α parameters, respectively, of the variable in question.
Source: Authors' calculations.

[9] The analysis has to apply identifying restrictions equaling the number of co-integrating restrictions minus one, that is, one in the present setting (this explains why all additional restrictions are testable in the case of one co-integrating relation, as this is exactly identified). We choose to restrict the parameter of construction in the first co-integrating relation to its estimated value, that is, take it as given. This merely means that further testing is conditional on this value being "true", that is, it cannot be tested.

Table 9. Restricted Co-Integration Relations, Aggregate Model

	β-eigenvectors			α-coefficients		
Country	Industry	Agriculture	Services	Industry	Agriculture	Services
Côte d'Ivoire	1.000	-1.000	-0.248	-0.240	0.646	0.000
Zimbabwe	1.000	-1.000	-1.000	-0.1054	1.049	0.000

Source: Authors' calculations.

Table 10. Restricted Co-integration Relations for Ghana, Sub-sectoral Specification

Manufacturing	Agriculture	Services	Mining	Construction	Gas and water
β- eigenvectors					
1.000	-0.2494	0.8591	-0.2293	-0.7479	-0.0178
-2.657	1.000	-1.283	-3.720	3.762	2.959
α-coefficients					
-1.224	0.000	0.000	-0.3475	0.000	0.000
0.07737	0.000	0.000	0.4215	0.000	0.000

Source: Authors' calculations.

For Côte d'Ivoire and Zimbabwe, we find an elasticity of unity between industry and agriculture, indicating full sectoral spillover from agriculture to industry following agricultural expansion. For Zimbabwe, service sector growth also spills over with a factor of unity. In the case of Côte d'Ivoire, the impact of the service sector is less than unity (25 percent). For both Côte d'Ivoire and Zimbabwe , the service sector is weakly exogenous to the system, implying that we may condition on services when modeling the I(0)-space. The disaggregated specification for Ghana is found to be driven by agriculture, services, construction, and gas and water since these sectors are weakly exogenous to the system. Therefore, we may reduce this system to consist of only the equations for manufacturing and mining (we do that in the next subsection).

These findings imply the existence of a sectoral feedback mechanism; sectoral expansion or productivity gains in either the industrial or agricultural sector feed back into the other sector. Additionally, these findings support the hypothesis that economic growth in these countries is partly led by the service sector (see Glasmeir and Howland 1994). One explanation of the positive link between agriculture and industry is that a larger and/or more productive agricultural sector can supply cheaper inputs for the food processing sector. This leads to an increased derived demand for primary agricultural products and, in turn, to increased agricultural sector demand for machinery and equipment produced by the industrial sector. Similarly, an expansion of the industrial sector requires increased input from agriculture.

The service sector plays an important role in sectoral growth, due both to its presence in the co-integrating relationship and to it being weakly exogenous to the system in all three cases. The expansion of the service sector has positive effects on industry and agriculture due to increased demand for agricultural and industrial sector input. This is true even though the service sector does not appear to utilize agricultural produce to the same extent as the food processing industry.

The intersectoral relationships can also be quantified by means of impulse response analysis, which traces the accumulated dynamic response of a hypothetical one-unit increase of each variable (see Hamilton 1994). The findings of the impulse response analysis support our earlier findings of a positive industry-agriculture link in sectoral economic growth (see figures 2, 3, and 4). For all three countries, there exists a positive impact on agricultural growth from an increase in the industrial sector (in Ghana: the manufacturing sector) over a ten-year period. For Côte d'Ivoire, the initial one-unit increase in industry leads to an increase of three units in the agricultural sector after 10 years. For Zimbabwe, the accumulated effect is almost two units, while for Ghana the increase is only one unit.

When investigating the agriculture-industry link in the other direction, that is, from agriculture to industry, there is at least an initial positive dynamic response in all three countries. In the case of Côte d'Ivoire, this response holds throughout the period; for Zimbabwe and Ghana, an adverse response follows after five to seven years. The service sector overall has a positive impact on the other sectors. For the remaining Ghanaian subsectors, the evidence is mixed.

Altogether, the results from the impulse response analysis support our earlier findings of a positive agriculture-industry link with service as an important growth-promoting factor. We now take the analysis a step further by modeling short-run sectoral growth.

4.2. Short-Run Sectoral Growth

The co-integration analysis of the previous subsection allows us to take the long-run information of the series into account in analyzing short-run sectoral growth, as the restricted co-integration relations determined previously may be included as explanatory variables. The resulting model is a short-run ECM.

The aim is to obtain a parsimonious model of short-run sectoral growth that is able to pass the specification tests. In the previous analysis, two lags (and a deterministic trend) were found to be appropriate for Ghana and Zimbabwe. A specification with one lag would be adequate because two lags in levels correspond to one lag in first-order differences. The same reasoning leads to an initial specification with four lags in the case of Côte d'Ivoire. However, when moving to first-order differences, the system for Côte d'Ivoire becomes severely afflicted by singularity problems, which persist at four, three, and two lags. Moving to one lag yields a specification with no singularity problems, which further passes the diagnostic tests (table 11). Because all three of the models already are relatively parsimonious and further reduction of individual variables affects the results of the diagnostic tests, we choose these specifications as our final, dynamic, short-run models. Tables 11, 12, and 13 present the models and the findings of the diagnostic tests.

Table 11. Dynamic Short-Run Sector Growth Model for Côte d'Ivoire

Explanatory variable	Equation		Explanatory variable	Equation	
	Industry	Agriculture		Industry	Agriculture
$Industry_{t-1}$	0.214	0.040	$Services_{t-1}$	0.415	0.408
	(1.320)	(0.224)		(2.042)	(1.815)
$Agriculture_{t-1}$	0.0199	-0.076	CI_{t-1}	-0.351	0.194
	(0.093)	(-0.321)		(1.912)	(0.956)
$Services_t$	-0.329	-0.202	Constant	-2.548	1.447
	(-1.856)	(-1.030)		(-1.899)	(0.975)

Diagnostics				
Single equation analysis	σ	$F_{ar}(1, 24)$	$\chi^2_{normality}(2)$	$F_{arch}(1, 23)$
Industry	0.078	0.970	2.517	0.135
Agriculture	0.086	2.685	2.615	0.032
Vector analysis	$F_{ar}(4, 44) = 2.159$, $\chi^2_{normality}(4) = 5.073$			

Note: Values in parentheses are t-statistics. Subscripts denotes the time period, i.e. t: current period, t-1: lagged one period, CI denotes the restricted co-integrating relation.
Source: Authors' calculations.

Table 12. Dynamic Short-Run Sector Growth Model for Zimbabwe

Explanatory variable	Equation		Explanatory variable	Equation	
	Industry	Agriculture		Industry	Agriculture
$Industry_{t-1}$	0.009	0.027	CI_{t-1}	-0.105	1.049
	(0.043)	(0.073)		(-0.827)	(4.459)
$Agriculture_{t-1}$	0.023	0.372	Constant	-2.084	21.408
	(0.217)	(1.943)		(-0.798)	(4.445)
$Services_t$	0.212	-0.355	Trend	-0.007	0.042
	(0.885)	(-0.802)		(-1.436)	(4.422)
$Services_{t-1}$	0.179	1.152			
	(0.774)	(2.706)			

Diagnostics				
Single equation analysis	σ	$F_{ar}(1, 23)$	$\chi^2_{normality}(2)$	$F_{arch}(1, 22)$
Industry	0.083	0.033	0.369	0.048
Agriculture	0.072	0.748	2.210	5.775*
Vector analysis	$F_{ar}(4, 42) = 0.279$ $\chi^2_{normality}(4) = 5.230$			

* Rejection at a 5 percent level of significance.

Note: Values in parentheses are t-statistics. Subscripts denotes the time period, i.e. t: current period, t-1: lagged one period, CI denotes the restricted co-integrating relation.

Source: Authors' calculations.

Table 13. Dynamic Short-Run Sector Growth Model for Ghana

Explanatory variable	Equation		Explanatory variable	Equation	
	Manufacturing	Mining		Manufacturing	Mining
$Manufacturing_{t-1}$	0.947	1.435	$Construction_{t-1}$	-0.341	-0.819
	(4.818)	(3.193)		(-2.145)	(-2.254)
$Agriculture_t$	0.151	-0.675	Gas and $water_t$	0.101	0.172
	(0.556)	(-1.088)		(1.054)	(0.786)
$Agriculture_{t-1}$	0.708	0.536	Gas and $water_{t-1}$	0.037	-0.246
	(3.032)	(1.004)		(0.527)	(-1.523)
$Services_t$	-0.663	-1.347	CI_1_{t-1}	-1.374	-0.337
	(-2.551)	(-2.266)		(-7.461)	(-0.801)
$Services_{t-1}$	0.010	-1.142	CI_2_{t-1}	0.020	0.425
	(0.032)	(-1.636)		(0.765)	(6.966)
$Mining_{t-1}$	0.148	0.746	Constant	21.245	7.627
	(1.682)	(3.707)		(7.617)	(1.196)
$Construction_t$	0.457	0.750	Trend	0.008	-0.037
	(3.671)	(2.631)		(1.974)	(-3.880)

Diagnostics				
Single equation analysis	σ	$F_{ar}(1, 15)$	$\chi^2_{normality}(2)$	$F_{arch}(1,14)$
Manufacturing	0.081	0.275	3.935	0.085
Mining	0.186	0.135	1.639	0.711
Vector analysis	$F_{ar}(4, 26) = 0.091$, $\chi^2_{normality}(4) = 5.230$			

Note: Values in parentheses are t-statistics. Subscripts denotes the time period, i.e. t: current period, t-1: lagged one period, CI denotes the restricted co-integrating relation.

Source: Authors' calculations.

Again, the importance of the agricultural sector is apparent. It has an overall positive impact on industrial growth (in Ghana: manufacturing growth). In Côte d'Ivoire and Zimbabwe, industry also has a positive impact on growth in the agricultural sector. These findings once again support the existence of a positive growth link between agriculture and industry. The positive dynamics between the agricultural and industrial sectors are the most robust findings across the three countries. For the service sector, there is evidence of a negative instantaneous impact, followed by a positive effect a year later. For the remaining Ghanaian sectors—mining, construction, and gas and water—there is mostly a positive impact.

There is some evidence of the industrial (manufacturing in Ghana) sector error correcting toward equilibrium, as the sign on the ECM term is negative, except for the second ECM term for Ghana. For agriculture, the parameter of the error correction term has the "wrong" sign.[10]

For all three countries, there are significant long-run sectoral relationships among the industry, agriculture, and service sectors. These relationships imply the existence of strong interdependencies in sectoral growth. These findings conflict with the basic dual economy model, which implies that there cannot exist a long-run relationship between growth in agriculture and industry. An overall positive agriculture-industry growth link is established for both the short and the long run. The service sector also proves important because it is weakly exogenous in all three cases, which implies that the service sector is an important growth-promoting sector.

5. Conclusion

This paper explores whether the experience of Côte d'Ivoire, Zimbabwe, and Ghana since 1965 supports the dual economy model. The empirical analysis of the sectoral components of growth in GDP in these three economies reveals the existence of one long-run sectoral relationship in Côte d'Ivoire and Zimbabwe but no co-integrating relationship in Ghana at the aggregate level. Since this could be due to the level of

[10] This implies that the various sectors adjust to deviations from equilibrium (which is the interpretation of the co-integrating relation): if the sector, following a positive shock, exceeds its long-run size, it will start adjusting toward its equilibrium size and vice versa for a negative shock. If they are positive, when

aggregation, we pursue an alternative specification with industry disaggregated into four subsectors. This specification reveals the existence of two long-run relationships. These findings point toward a large degree of interdependence in sectoral growth. Furthermore, they provide evidence against the basic dual economy model, which implies that a long-run relation cannot exist between agricultural and industrial output. The findings are supported by the impulse response and short-run analyses that both point to a positive link between growth in the industry and agriculture sectors.

Many developing countries looked toward the experiences of industrial economies in the period following World War II and adopted policies favoring the industrial sector at the expense of the agricultural sector. Many African countries followed this road during the 1960s and 1970s. The analysis shows that in Côte d'Ivoire, Zimbabwe, and Ghana, this policy of focusing mainly on industry is not optimal. It would be more effective and efficient to balance policies to include all sectors, whereby economywide growth would gain the maximum from the positive externalities of sectoral growth.

The policy implication emerging from this study is that more attention should be paid to the intersectoral dynamics in Sub-Saharan African economies for two reasons. First, an adverse shock—for example, in agriculture following a drought—is likely to cause adverse effects in the other sectors of the economy. Hence, policymakers should try to accommodate not only the initial shock in the agricultural sector, but also its adverse effects on the other sectors. In practice, when a severe drought occurs, the majority of the attention is drawn toward the agricultural sector. Second, the presence of intersectoral dynamics indicates externalities from sectoral expansion, that is, when one sector grows it will have dynamic effects on the other sectors. This should be taken into account by balancing funds across the agriculture, industry, and service sectors, rather than focusing on, say, one or two sectors.

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experiencing a positive shock, the sectors react by expanding and would thus diverge over time. Similarly, following an adverse shock, they would start degenerating.

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Appendix

The augmented Dickey-Fuller (ADF) test starts out from the regression:

$$(\text{A-1})\ \Delta z_t = a + bt + cz_{t-1} + \sum\nolimits_{j=1}^{J} d_j \Delta z_{j-1} + \varepsilon_t$$

where c=ρ-1.

The ADF test for a unit root against the (trend) stationary alternative is then:

H_0: z has a unit root, z~I(1), i.e. c=0
H_1: z is (trend) stationary, z~I(0), i.e. c<0.

From the results of the ADF regression (two lags) presented in table A-1, there do not seem to be any serious problems with autocorrelation, although industry shows some indications of autocorrelation at a 5 percent level of significance.[11] The results of the ADF tests support the presence of a stochastic trend in the series, and thus support that the series are integrated of order one, I(1). It should be noted, however, that the ADF test has low power, so that we will tend to under-reject the H_0 of integration even if it is false, especially in small samples.

Table A-1. Augmented Dickey-Fuller Tests and Misspecification Tests for ADF Regressions

Country and sector		
Côte d'Ivoire	ADF t-statistic	$F_{ar}(1, 24)$
Industry	-2.059	1.923
Agriculture	-3.043	1.548
Service	-2.478	0.310

[11] The ADF test is sensitive to the presence of autocorrelation; see, for example, Banerjee *et al* (1993).

Zimbabwe	ADF t-statistic	$F_{ar}(1, 24)$
Industry	-2.328	5.428*
Agriculture	-2.634	0.133
Service	-3.437	3.860
Ghana	ADF t-statistic	$F_{ar}(1, 23)$
Manufacturing	-1.447	0.737
Agriculture	-2.533	1.110
Service	-0.785	1.083
Mining	-1.232	1.558
Construction	-0.949	3.510
Gas and water	-1.625	0.713
Industry	-1.140	6.173*

* Rejection at a 5 percent level of significance.

Source: Authors' calculations.

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